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“There is no better way to study science than to collect and analyse data in your own yard”: outdoor classrooms and primary school children in Bangladesh.

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Abstract

The design and use of outdoor spaces for primary school teaching and learning has been given little consideration in the present context. The existing evidence base is mostly from western perspectives. In this study, an outdoor classroom was designed and built in a primary school in Bangladesh and used to teach children (n=30) their science curriculum. Multiple methods were used to investigate the impact of the outdoor classroom on students’ learning and engagement, including achievement tests, a questionnaire and focus groups with children and teachers. Children’s science scores were significantly higher after they had been taught outdoors, compared to indoors. Physical qualities of their outdoor classroom (lighting, acoustics, seating), in addition to greater enjoyment and active participation in learning likely explained improved attainment. Qualitative insights from children and teachers supported the quantitative findings. These results provide empirical support for building outdoor classrooms as an effective environment for teaching and learning.

Keywords: outdoor classroom, science, mixed methods, attainment, engagement, Bangladesh

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Introduction

Primary schools are typically the first formal institution in which children learn. Therefore, the influence of school and/or classroom design on children's learning is becoming of increasingly interest in the fields of education, architecture and design. The outdoor environment of primary schools, although a sizeable element of the primary school premises, is often ignored in school-design, as it is not typically used for formal instruction (Armitage & Burke, 2005; Kasali & Dogan, 2010). Indeed, the design of school grounds and its potential impact on children's learning has not attracted the same level of interest as the design and space within classrooms (Armitage & Burke, 2005; Barrett, Davies, Zhang, & Barrett, 2015; Kellock & Sexton, 2017). Despite this, a growing body of research has associated spending time in the outdoor environment with attention restoration, recovery from stress, informal learning through play, improved physical activity and improved academic attainment (Chawla, Keena, Pevec, & Stanley, 2014; Mårtensson et al., 2014; O'Brien, 2009; O'Brien, Murray, Liz, & Richard, 2007; J Roe & Aspinall, 2011; Ward Thompson & Aspinall, 2011).

With regard to developing countries specifically, a recent report published by UNESCO illustrates that the net enrolment rate of children in primary schools across the world has increased over recent years; however more than 59 million primary school-aged children are still out of school and school retention is particularly problematic (UNESCO Institute for Statistics & UNICEF, 2015). This scenario is pronounced in Asia and Africa (e.g. MacKenzie, Moffatt, Ogwang, Ahabyona, & Sengupta, 2017). In Bangladesh specifically, the drop-out rate is 20.9%; approximately 0.6 million children do not continue their primary education (BANBEIS, 2015). There are number of reasons for this; poverty and a dislike of school (Ahmed, Nath, & Hossain, 2005) and a boring and unattractive school environment (Chowdhury, Chowdhury, Hoque, Ahmad,

& Sultana, 2009) have been cited as some reasons for dropping out. Despite this, the design of the school environment is typically ignored as a possible way to increase retention, although there is evidence of the positive impact that a school's design can have on children's academic achievement and engagement (Tanner, 2000, 2009).

In Bangladesh, the classrooms in most Government primary schools (GPS) are designed following the international school design standards set by UNESCO – 40 students per class and 10 ft² per pupil (DPE, 2014). Good quality physical environment is defined as *pucca*² 26' x 19'6" classrooms, however the classroom size in the newly constructed buildings is smaller: 17' x 19'6" (DPE, 2014) (see Figure 1 for the view inside a classroom). Improving the schools' physical environment typically means adding more classrooms to the existing building or constructing a new building and abandoning the previous dilapidated one. Currently in Bangladesh, approximately 38000 Government primary schools exist with such design (BANBEIS, 2015). These schools are attended by approximately 10 million children. Almost all of these primary schools own an open yard in front of the school building, following the requirement for a mandatory 0.33 acre of land for primary schools. However, these school grounds are often under or un-utilised, being barren and devoid of any elements for formal or informal learning (Khan, 2009; Samborski, 2010). The average class size is 54, however the number of students in a class varies from 20 to 80 (Hossain, Kalam, Cameron, Uddin, & Ahmed, 2009). Attendance rate in schools averages at 74% and the average teacher student ratio across schools is 1:61 (Hossain et al., 2009).

² Made with durable materials



Figure 1: Inside the classroom of a typical Government Primary School (in Narsingdi)

The classrooms in most of these GPSs are poorly designed with inadequate light and ventilation. They are also typically overcrowded; the classes are typically lined with benches, providing no scope for innovative learning opportunities, experimentation or exploration. These limited resources (i.e., lack of space and materials) prevent teachers from using a range of instructional activities and give fewer chances to follow up students' performance in the class (Ayvaci & Devecioğlu, 2010; Rabbi, 2005). In total, 70% of teachers receive subject based training each year and all teachers receive sub-cluster training (DPE, 2009). Implementing the knowledge learnt during training requires some infrastructural facilities which current classrooms typically do not offer.

Given the poor physical environment inside primary schools in Bangladesh, and emerging evidence of the benefits of spending time outdoors, this study explored the potential of an outdoor classroom to improve children's learning and engagement.

Outdoor environment and children's learning and well-being

Research examining children's outdoor environments has changed over recent years (Nor Fadzila & Ismail 2012). From a synthesis of 30 empirical studies focusing on

children's environment between 1985 and 2010, play has consistently been found to be a central topic. In more recent years however, there has been an increase in the number of studies focusing on natural environments and the role of design in encouraging activities outdoors (Cosco, Moore, & Smith, 2014; Hussein, 2010; Kelz, Evans, & Roderer, 2013; Park, O'Brien, Roe, Thompson, & Mitchell, 2011).

Studies focusing on the outdoor environment and learning are typically interdisciplinary, drawing upon insights from education, landscape architecture, geography, public health and sports science. Researchers in the field of education have been keen to explore the relationship between 'greenness'³, outdoor play and children's environmental learning (Dyment, 2005; Grant & Littlejohn, 2001; Lucas & Dyment, 2010; Malone & Tranter, 2003; Tranter & Malone, 2004). Research in landscape architecture, environment-behaviour studies and public health, on the other hand, has primarily investigated the impact of the playground design on children's physical activity and play (Anthamatten et al., 2011; Chawla et al., 2014; Jansson, Gunnarsson, Mårtensson, & Andersson, 2014; Mårtensson et al., 2014; Willenberg et al., 2010). Despite clear reasons to study the potential of outdoor environments to support children's formal learning, there are few studies in this area. However, relevant studies include those that have explored the benefits of forest schools on children's physical activity, motivation and well-being (Gambino, Davis, & Rowntree, 2009; Hart, 1982; Lovell, 2009; O'Brien, 2009; O'Brien et al., 2007; Roe & Aspinall, 2011). Rickinson et al. (2004), in their review of research on outdoor learning noted that most studies are descriptive, poorly conceptualised, designed and/or inadequately executed.

³ The exposure to trees and vegetation

In terms of the influence of the physical environment on children's learning, The University of Georgia's 'School Design and Planning Laboratory' devised 39 patterns of school design in which movement and circulation pattern, daylight and classrooms with views were found to be associated with children's performance in certain academic areas (Tanner, 2000, 2009). Light, temperature, air-quality, ownership, flexibility, complexity and classroom colour were found to influence children's learning in another study by Barrett et al., (2015). For example, classrooms with green walls can positively influence children's subjective well-being found in a study by Berg, Wesselius, Maas, & Tanja-Dijkstra, (2015). In addition to physical and aesthetic properties of the building or classroom, researchers have also investigated the influence of taking formal learning outdoors on children's academic performance. In accordance with the idea of Piaget (Inhelder & Piaget, 1969) and Montessori (1964), children are more engaged in their activities in an outdoor environment (Boaventura, Faria, Chagas, & Galvão, 2013; Isaacs, 2007; Maynard, Waters, & Clement, 2013). In a study of 40 schools, it was found that students attending schools where the outdoor Environment was used as an Integrated Context (EIC) reported higher academic achievement in reading, writing, math, science and social science compared to children who attended schools with indoor classrooms (Lieberman & Hoody, 1998). The students from the EIC schools also demonstrated increased engagement and enthusiasm for learning and reduced behavioural problems. In a further study as part of the same project, EIC students performed significantly better in mathematics and science tests than the students taught in the indoor classroom (Lieberman, Hoody, & Lieberman, 2005; Lieberman, Hoody, & Lieberman, 2000).

To date, very few studies have explored the potential of the outdoors as a teaching and learning environment in the context of developing countries. The only

study we know, is a pilot project focusing on outdoor primary education in Bangladesh, conducted in 1976 (Choudhury & Obaidullah, 1980). In this study, outdoor education was introduced across 6,250 primary schools in 94 sub-districts (which included approximately one million children and 25,000 teachers) for approximately three months. This was implemented due to a bumper production of crops, which resulted in schools being used temporarily for storage. Rather than closing down the schools, they were called ‘*muktangon*’ or open air primary schools and a research study was designed to investigate the potential of outdoor education. The project was evaluated based on interviews with teachers and children from 224 *muktangon* schools and attendance data was compared with 42 non-*muktangon* schools. The research found that 77% of the schools reported a 9% increase in student attendance on *muktangon* days compared to non-*muktangon* days. Though the evaluation team recommended continuing the project in all the schools of 15 selected sub-districts, no follow up report can be found. The present study was designed to further investigate the efficacy of an outdoor classroom as a place for teaching and learning for primary school children in Bangladesh.

Methods

A quasi-experimental mixed methods study was conducted in a Government primary school in the sub-district of Raipura, about 90 kilometres from Dhaka, the capital city of Bangladesh. The school was typical of Government primary schools in built environment design characteristics (i.e., follows standard modular design and possesses the mandatory 0.33-acre land area) and demographics of the children (primarily from farming communities). This was a rural school, as in developing countries, rural children are more likely to play truant, less likely to stay in the school and perform more poorly in their exams (Chowdhury et al., 2009). Written permission was sought from

the Headteacher and oral permission from the parents before the intervention and data collection. Children's assent to participate in the study was also taken.

Study Sample

Fifty-two students were enrolled in Grade IV (aged 9-10 years old), however the attendance rate was very low. Only thirty children participated in both the indoor and outdoor classroom and completed both achievement tests and questionnaires and these children are included in the analysis. The same group of children were taught initially in their indoor classroom, followed by the newly constructed outdoor classroom (amphitheatre) (see Figure 2).

Children aged 9-10 were selected for two reasons. Firstly, it was felt that the research methods used in this study would be developmentally appropriate for children of this age (i.e., questionnaires and focus groups) (Greene & Hogan, 2005). In addition, in primary schools in Bangladesh, the drop-out rate is highest among Grade IV students (BANBEIS, 2015), therefore identifying potential routes to increase school engagement and retention among students of this age is crucial.

Design and Intervention

An outdoor classroom (amphitheatre) was designed and developed specifically for this study. A number of considerations were made during the design of the outdoor classroom. Firstly, the seating area was designed to consider the distance and angles between the children and the teacher (to ensure all children could see the teacher and the teacher could clearly view all the children). Secondly, a large blackboard (for display and writing) was positioned to ensure all children could view the blackboard and ensure children of any height could write comfortably. Thirdly, a stage was created for working on, storage was created and a worktop was added for experiments. Therefore,

there were a number of features which differed between the indoor and outdoor classrooms (e.g., seating/view of teacher, air flow, lighting, acoustics), in other words, the indoor classroom environment was not recreated outdoors.

Children were taught two consecutive chapters of their science book in the classroom and then two chapters outdoors by their science teacher. The same teacher taught the same children in both environments and both chapters were taught over the same period of time (4 days). The delivery of the content depended solely on the teacher and the authors did not intervene during the teaching process.

Children were taught Chapter 1 of their science text book in the classroom; this chapter focused on the classification of plants⁴. After one week, children were assessed on their knowledge and understanding of this topic. Children then received approximately two weeks of teaching and learning in the amphitheatre, to allow them to become accustomed to the outdoor classroom and reduce the potential influence of novelty on the outdoor classroom outcomes. The following week, children completed the second book chapter in the amphitheatre which focused on soil⁵ and were assessed on their knowledge and understanding of this topic one week later.

⁴ The 'Classification of Plants' chapter covered: the purpose and importance of classification, identifying groups of plants based on their characteristics, different parts of a plant, and comparing and contrasting plants to identify special characters that distinguish one plant group from other.

⁵ The soil chapter covered: the definition of soil, different types of soil, which plants grow in which type of soil, reasons of soil erosion and how to prevent it, different types of manure and how to make compost and green fertiliser from organic materials.



Figure 2: Children in their outdoor class

Data Collection Methods

Four approaches were used to collect data to examine children's learning in the two environments. Indeed, a combination of qualitative and quantitative methods were applied for a more holistic picture (Jick, 1979) and accurate results (Monsoureh & Ismail, 2012). These included achievement tests to measure children's knowledge and understanding of the topics covered in both environments, a questionnaire to compare children's perceptions of both environments (physical features, learning enjoyment and participation) and focus groups with children and teachers, to allow in-depth qualitative insights into the teaching and learning experiences in the indoor and outdoor classrooms

Achievement test

Two achievement tests (plants and soil) were developed to assess children's knowledge and understanding of the topics taught in the two different environments. The structure of the test was motivated by the primary achievement tests developed by Haq (1994) and the formulation of the test followed the process adopted by the author. An independent researcher familiar with the curriculum checked the content of both assessments to check they were comparable in terms of difficulty. Prior to

administration, the tests were piloted with a comparable group of Grade IV children in another Government primary school within the same sub-district. Based on the pilot test, some minor adjustments were made in the language and content of the achievement tests. The tests were administered in Bangla.

Each of the achievement tests comprised of seventeen questions of which sixteen were multiple choice questions (children received 1 score for each correct answer) and one question asked children to identify two elements in an image (one score for the correct identification of each element). Hence, the total score for each achievement test was 18. See Appendix 1 for example items from the two achievement tests. The achievement tests were taken one week after completion of each chapter, but without prior notice. The teachers were not informed of the content of the achievement tests to ensure confidentiality of the test tool.

Children's Questionnaire

A self-report questionnaire was used to gain insight into children's perception of the quality of the built environment (light, acoustics and seating), enjoyment of learning and participation in indoor and outdoor classrooms. The children completed the questionnaires in the environment they studied (i.e., the questionnaire about indoor learning was completed indoors and the outdoor learning questionnaire was completed outdoors). The questionnaires were administered in Bangla and children were given instructions on how to complete the questionnaires (i.e., the four-point Likert scale was explained and all children completed one example item). Each questionnaire item was then read, to ensure reading skill did not influence completion, following the protocols used by Mygind (2007). For the questionnaire items and response scale (translated following a forward-backward strategy from the original Bangla version) please see Appendix 1.

Focus groups with children and teachers

In order to gain insight into children's perceptions and experiences of the two different settings, qualitative information was sought through focus groups with children and teachers separately. Three focus groups with the children took place in the outdoor classroom as there was insufficient space to conduct them indoors. Each focus group comprised six to eight participants. In addition, six teachers from the school participated in one focus group, which took place inside the office room. The focus group discussion (FGD) was semi-structured and explored topics including children's views of having science classes outdoors, how the outdoor classroom helped or deterred science learning, what other subjects could be taught in the outdoor classroom and children's participation and engagement in learning outdoors.

Data analysis

Paired samples t-tests in IBM SPSS 22 (2013) and thematic analysis were carried out using the quantitative and qualitative data respectively. Using data from the achievement tests and the questionnaire, paired samples t-tests were carried out, to examine to what extent the two different environments influenced children's academic attainment, perceptions of their physical environment and their enjoyment of learning and participation. The qualitative data generated from the focus groups were analysed using thematic analysis as outlined by King (2010). One of reasons for choosing thematic analysis is the flexibility in its process; it is not theoretically bounded like grounded theory or interpretive phenomenological analysis (Braun & Clarke, 2008). Thematic analysis is more recursive than following one phase to the next and involves a constant moving back and forth throughout the whole process (Braun & Clarke, 2008).

Results

Academic attainment

A significant difference was found in children's academic attainment; children performed significantly better after being taught in the outdoor classroom compared to indoors; $t(29)=-8.83$, $p<0.001$ (see Table 1). Scores were split into low (0-6), medium (7-12) and high (13-18) levels of attainment (see Figure 3). Using this distinction, 60% of the students achieved a low score after being taught indoors, whereas only 10% achieved low scores after being taught outdoors.

Table 1: Mean scores and standard deviations in children's achievement test and questionnaire items

Items	Mean (Standard Deviation)	
	Indoor classroom	Outdoor classroom
Achievement Test	5.13 (3.50)	10.07 (2.70)
Lighting	3.03 (0.32)	4.00 (0.00)
Acoustics	1.17 (0.65)	3.90 (0.31)
Seating	2.13 (0.57)	3.83 (0.53)
Enjoyment of learning	1.97 (0.49)	3.87 (0.35)
Participation	2.87 (0.35)	3.80 (0.41)

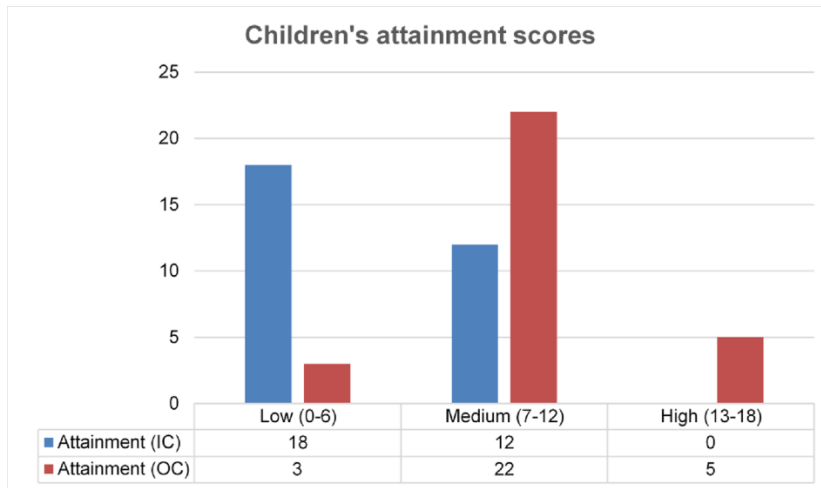


Figure 3: Children's attainment (low, medium and high) after being taught in the indoor classroom (IC) and outdoor classroom (OC)

Physical environment

A significant difference was found in children's opinions of the physical environment in the indoor and outdoor classroom. Children reported that the lighting [$t(29)=-16.55$, $p<0.001$], acoustics [$t(29)=-21.65$, $p<0.001$] and seating [$t(29)=-15.62$, $p<0.001$] were significantly better in the outdoor classroom (see Table 1). For example, over 70% children described the acoustics and seating as poor or very poor in the indoor classroom, but over 90% reported that the acoustics and seating were very good in the outdoor classroom (see Figure 4).

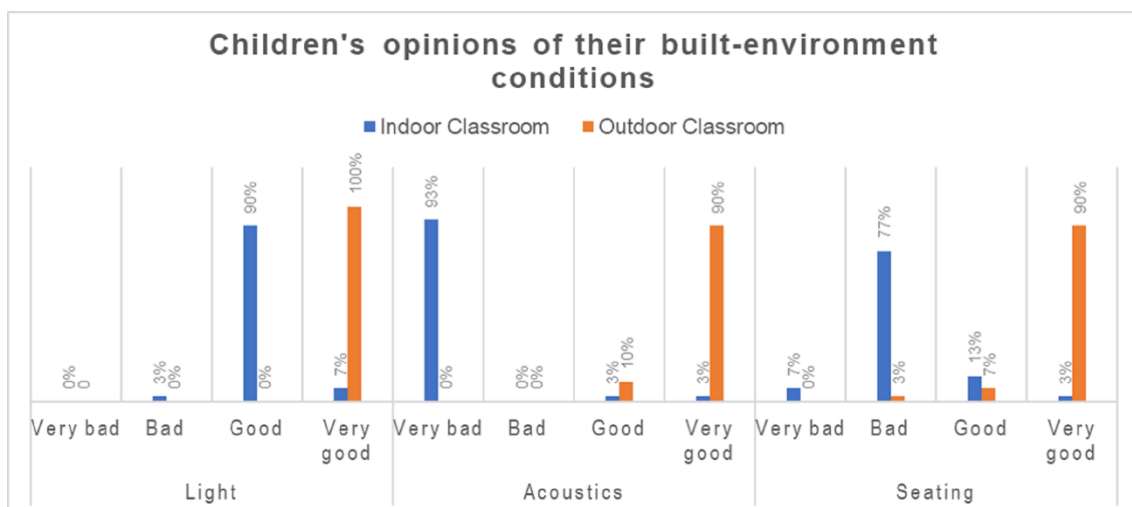


Figure 4: Children's opinions of their built environment conditions in the indoor and outdoor classrooms

Children's enjoyment of learning and active participation

In addition, children reported enjoying science learning significantly more in the outdoor classroom compared to indoors, $t(29)=-17.13$, $p<0.001$ and greater active participation in class tasks was reported in the outdoor classroom, $t(29)= -9.82$, $p<0.001$ (see Table 1 and Figure 5).

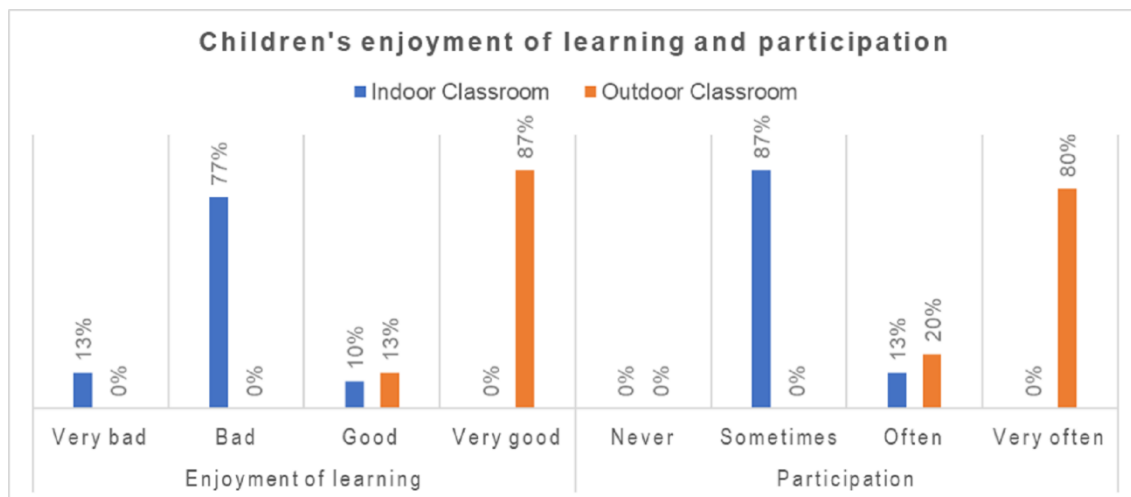


Figure 5: Children's enjoyment of learning and participation in the indoor and outdoor classrooms

Qualitative insights into outdoor learning

Thematic analysis of the focus groups revealed considerable similarity in terms of the main themes which emerged across the groups. The main themes emerged during the analysis are discussed below.

Opportunities for exploration, collaboration and connecting with nature

All of the children were unified in their opinion that outdoor classes offer more opportunities for exploration, experimentation and collaboration, which they considered a very effective way to learn science. According to them, there was sufficient space and scope for experimentation in the outdoor class which they missed indoors: *'The classroom gets dirty if we do any experiment and it's difficult to clean the classroom, so hands on teaching is avoided (by teachers). On the other hand, it is much easier to do any experiment in the outdoor*

class' (Boy 1). *'All the elements we learn such as trees, animals, soil, air and water are around us in nature, which the teachers can refer to during the classes outdoors'* (Girl 3).

The teachers also mentioned easy access to the elements of nature when teaching science: *'While teaching the chapter of "Soil", I could ask a child to bring some soil from the school ground or nearby ditch when I teach them about different types of soil'* (Science teacher Ms S). The science teacher stressed, *'There is no better way to study science than to collect and analyse data from your own yard.'* In the indoor classroom, children were separated from nature, required to learn what they could not directly see or touch.

The children also said that they could not engage in collaborative activities in the indoor classroom because of the lack of space and configuration of the benches, which allowed little opportunity for pupil movement and circulation. However, the situation was different outdoors: *'We work in groups in the outdoor class. While Girl 1 was separating the crops of clayey soil from all other crops, I was writing their names on the blackboard. Others were checking if I was doing any wrong and correcting the spelling mistakes. Everybody is participating which never happened in the classroom'* (Boy 2). FGDs with children and teachers also revealed that only the children seated at the front desk participated in tasks in their classroom, due to the physical restrictions of the classroom layout. According to the teachers, the children who sat at the back never responded, they sat as the 'passive learners'. According to the children, the outdoor classroom offered equal opportunities for participation to all.

Physical environment

Children also spontaneously shared their views on the differences in physical environment. According to them, there was insufficient light indoors. The children sitting near the windows had better light, but the lighting conditions were poor in other parts of the indoor classroom. Children also felt there was insufficient air flow. They

also complained that they could not hear their teacher very clearly as sound travelled easily from the next classroom. The teachers also complained about the poor acoustic conditions of the classroom as they could not hear the children sitting at the back. On the other hand, the outdoor classroom was full of light, the children felt comfortable because of the natural air flow, and there were no annoying noises: *'It is peaceful in the outdoor classroom with so much light and the shade of the tree. There is no noise travelling from the next class; you can rather listen to the chirping of birds'* (Boy 1).

Comfortable seating, ease of movement and better visibility were some of the prime features of the outdoor classroom, as expressed by children in the focus groups: *'The benches in the classroom are not comfortable, some are broken and some just move back and forth'* (Girl 2). *'If the tall students sit in the front rows, the smaller ones can't see the blackboard. We can't even see the teacher sometimes if she shows something from the textbook'* (Girl 8).

Children who sat beside the window indoors also had difficulty seeing the blackboard because of the glare. According to all of the children participating in FGD, in the outdoor class, they could sit comfortably, move easily and could see and access the blackboard whenever they wanted (due to the elevated position of the back seats in the amphitheatre). Indeed, the outdoor classroom ensured all children could have eye-contact with their teacher and could see their peers too. They could also carry out experiments on the front platform which was visible to every child. The blackboard was also large enough, and all the students could see it sitting from every corner of the amphitheatre. According to the teachers, they also felt confident while teaching in the amphitheatre as they could see the facial expressions of every child; this was often not possible in the classroom.

Opportunities for teaching subjects other than science

When asked which subjects could be taught in the outdoor class, both the students and

the teachers expressed the same opinion that any subject could be taught in the outdoor classroom. The children enjoyed learning outdoors and learnt through play amidst nature: *'The children are spontaneous and enthusiastic in their outdoor class. The inertia which is observed in them in the classroom is never seen in their outdoor class' (Teacher Ms S)*. The teachers specifically mentioned teaching numeracy at lower grades where leaves, seeds or sticks could be easily collected from nature to teach children how to count, add, subtract, multiply or divide. One of the teachers also mentioned rapid reading and other co-curricular activities like singing, dancing, play and story-telling. In Government primary schools in Bangladesh, the preschoolers are not allocated any classroom because of the lack of classrooms. Previously they were taught in the verandah, but after the completion of the outdoor classroom, they got a classroom. The outdoor classroom was also used for free play by children and for parents' meetings with teachers.

Discussion

The study was conducted as a result of the poor quality classroom environments in Government primary schools (Nath, Mushtaque, & Chowdhury, 2010) and striking drop-out rates (Chowdhury et al., 2009) in Bangladesh primary schools. The main aim of the study was to examine whether, and to what extent, the primary school outdoor environment was supportive of children's learning of the curriculum. In this small scale study, statistically significant gains were found in science achievement, perceptions of the quality of their physical environment, reported learning experiences and participation. These quantitative findings were supported by qualitative insights from both students and teachers. These findings echo those of past researchers (Lieberman & Hoody, 1998; Lieberman, Hoody, & Lieberman, 2000; Lieberman, Hoody, & Lieberman, 2005).

With regard to physical features, the acoustics and seating were particularly improved outdoors. These basic elements of the child's physical environment are often taken for granted by educators and designers, yet, as evidenced by the focus groups, are critical for learning and engagement. There is a distinct lack of research comparing indoor and outdoor school environment conditions in developing countries; however, past research does illustrate that better lighting conditions in the classroom positively influence children's academic attainment (Barrett et al., 2015; Tanner, 2000, 2009).

Interestingly, while there were overall gains in children's science attainment, the most significant gains were among lower achievers; substantially fewer students received a low score after being taught in the outdoor classroom. This resembles the findings from research conducted in the UK (Maynard et al., 2013; Singal & Swann, 2011). In addition to changes in attainment, children also reported greater enjoyment of science learning after learning outdoors and greater participation; this also echoes the findings of previous research (Gambino, Davis, & Rowntree, 2009; Lieberman et al., 2000).

The qualitative findings support the quantitative results and provide useful additional insights. For example, children previously described as apathetic about science classes participated in their outdoor science classes with greater enthusiasm and motivation. While only based on a single school, these findings suggest that outdoor learning in a relatively formal environment (i.e., amphitheatre) can have a positive influence on primary school children's learning in Bangladesh. The National Education Policy 2010 of Bangladesh states that knowledge of science should be imparted at a very early stage, acquainting children with nature and the environment (Ministry of Education, 2010). The outdoor environment therefore could be used across a range of primary school stages. However, it is important to bear in mind that outdoor classrooms

should not replace the existing indoor classrooms, rather they should be considered an extension of the indoor classroom for effective delivery of the curriculum.

Limitations and directions for future research

Firstly, it is important to note that this study was carried out in a single school with a relatively small group of students, which could arguably undermine the extent to which these findings can be generalised. Nevertheless, this school shares many characteristics in terms of indoor infrastructure/design and potential for outdoor development with all Government primary schools across Bangladesh. Secondly, with regard to the questionnaire, only a single question was used to examine each area of interest (e.g., acoustics, participation etc). In future, several questions for each construct would improve construct reliability. In addition, future questionnaires could also examine other important constructs likely to be of interest (e.g., motivation and engagement in learning). Thirdly, the achievement test tool was developed by the first author (but independently examined for comparability by an independent researcher). Developing the achievement test was necessary, to ensure the questions linked specifically to content taught in the indoor and outdoor classroom. Nevertheless, conducting this research across two schools (or two groups within a larger school) and counterbalancing the order of teaching (i.e., indoor-outdoor vs outdoor-indoor) and content of topics taught in each setting (i.e., indoor-plants, outdoor-soil vs indoor-soil, outdoor-plants) would have accounted for any differences that may have arisen based on order or content of assessments. Fourthly, throughout the manuscript, reference is made to an indoor and outdoor classroom, however these classrooms differed in a number of characteristics (e.g., seating, view of teacher/students, acoustics, lighting etc). This study therefore does not provide a direct comparison of the same learning environment indoors vs outdoors. Instead it examines what is achievable and optimal to build

outdoors, on a relatively small budget, to improve children's learning. Future research should consider the extent to which an outdoor classroom has the potential to increase children's motivation to learn, school attendance and retention rates. Another potential area is children's engagement in the design of their outdoor learning environment and future research can look into how that might create an agency among children and influence their learning and well-being.

Conclusion

This mixed method research study suggests that in the context of developing countries, where indoor classroom design/conditions are poor, there is considerable potential in taking learning outdoors. Although small in scale, this study suggests that outdoor learning leads to significant improvements in the child's physical environment (lighting, acoustics, seating) and greater enjoyment of learning and participation. These factors, combined with others highlighted in the focus groups, led to significant improvements in science achievement, particularly reducing the number of students attaining poor scores. It is essential to develop this research area and rigorously examine the design and conditions of school environments in developing countries, to ensure all children have the best possible opportunity to achieve their potential.

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Appendices

Questionnaire items (translated from Bangla)

1. How is the lighting condition for studying in the classroom/outdoors?
 - I can read very well (very good)
 - I can read moderately well (good)
 - I can somewhat read (bad)
 - I cannot read at all (very bad)
2. How is the acoustical condition of the classroom/outdoors?
 - I can listen to the teachers very clearly (very good)
 - I can listen to the teachers moderately clearly (good)
 - I can somewhat listen to the teachers (there is some noise from other classrooms or the street) (bad)
 - I cannot listen to the teachers at all (it is very noisy with sound travelling from the other classrooms or the street) (very bad)
3. How is the seating condition in the classroom/outdoors?
 - The seating is very comfortable (very good)
 - The seating is moderately comfortable (good)
 - The seating is not comfortable (bad)
 - The seating is not comfortable at all (very bad)
4. How do you feel about learning science in the classroom/outdoors?
 - I enjoy it very much (very good)

- I moderately enjoy it (good)
 - I somewhat enjoy it (bad)
 - I do not like it at all (very bad)
5. How often do you actively participate in learning in the classroom/outdoors?
- Very often
 - Often
 - Sometimes
 - Never

Example items from Achievement Test 1: Plants (translated from Bangla)

1. Which one is a non-flowering plant?
a) Fern b) Sunflower c) Paddy d) Chilli
2. Which of the following groups has elements with same properties?
a) Fern, mushroom, algae b) chick peas, mustard, moss c) rice, wheat, mushroom
d) mango, berry, pine
3. What do you see when observing a leaf of a fern?
a) Sorus – a granular element b) the seed alongside the leaf c) a green velvety texture d) the leaf is not green

Example items from Achievement Test 2: Soil (translated from Bangla)

1. The rotten bits of dead animals and plants create –
a) Manure b) sandy soil c) humus d) aggregate
2. Which type of soil contains equal parts of sand, water and clay?
a) Sandy b) clayey c) silty d) loamy

3. If you take a handful of soil and gently squeeze it and the lump crumbles apart, what type of soil is this?

a) Clayey b) sandy c) silty d) loamy